ORIGINAL RESEARCH

REFERENCE VALUES FOR THE CLOSED KINETIC CHAIN UPPER EXTREMITY STABILITY TEST (CKCUEST) FOR COLLEGIATE BASEBALL PLAYERS

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ABSTRACT

Background. The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) is a tool developed and used in the clinic to evaluate progress during upper extremity rehabilitation. A need exists for reference values of CKCUEST for use in a clinical setting.

Objectives. To calculate reference values for the CKCUEST that may assist clinicians in developing goals and objectives for male collegiate baseball players who are recovering from injuries to the upper extremity. To determine if differences exist in scores according to playing position.

Methods. The sample consisted of 77 collegiate, male baseball players between the ages of 18 and 22 who reported no recent history of injuries to the shoulder, elbow, or the hand-wrist complex. The CKCUEST was administered three times to the athletes and the number of touches when performing the CKCUEST during the 15-second test was measured and recorded. An average of the three tests was used for data analysis.

Results. No significant differences existed according to playing position. The data did not differ from the normal distribution; therefore, reference values were calculated and reported for use by clinicians in development of goals and objectives for this population.

Discussion and Conclusion. The CKCUEST appears to be a clinically useful test for upper extremity function.

Key Words: upper extremity, functional testing, closed-kinetic chain

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INTRODUCTION

In the college baseball population, injuries to the upper extremities are very common, as throwing and batting activities place an enormous amount of stress on the joints of the upper extremity.[1] Fifty-eight percent of all injuries in collegiate baseball involved the upper extremity and accounted for seventy-five percent of the total time lost from sport, longer than injuries to other parts of the body.[1] Pitchers sustain the majority of upper extremity injuries, as the intense, repetitive throwing that pitching requires places a greater amount of stress on the upper extremity compared to other positions.[1] Throwing a baseball produces rotational velocities greater than 6000 degrees per second; and, at the point of release, distraction forces at the glenohumeral joint can be one to one and a half times the athlete's body weight.[2] Because throwing places so much stress on the upper extremity, the athlete must have adequate strength, stability, and mobility in order to return to activity after injury. If the athlete returns to activity too soon, re-injury may occur rather easily.

A closed-kinetic chain activity is defined as an activity in which the terminal joint meets considerable external resistance which prohibits or restrains free motion; whereas, an open-kinetic chain activity is defined as an activity in which the terminal joint is free.[3] Most of the activities in baseball are open-kinetic chain movements. However, an increase in the use of closed-kinetic chain activities in clinical rehabilitation has occurred to help return the athlete to their sport. Closed-kinetic chain activities may help improve dynamic stability through joint approximation and co-contraction.[4] Compression from closed-kinetic chain activity also stimulates mechanoreceptors and helps improve proprioception.[4] These improvements may be important when determining if the patient is ready to return to activity.

A need exists to develop tests that provide objective data to help clinicians determine a patient's readiness to return to activity. These tests should be easy for clinicians to use and for patients to understand. The tests should also be cost efficient and require minimal space in the clinic.[4,5] The closed-kinetic chain upper extremity stability test (CKCUEST) is intended for these purposes. The starting position for performing the CKCUEST is a traditional push-up position. The subject maintains this position while touching with one hand the ground on their opposite side. The score on the test is the number of touches completed in 15 seconds.[4,5]

To be useful in the clinical setting, reference values for the CKCUEST are needed to assist the clinician in developing goals and objectives for their clients. The purpose of this study is to establish a set of reference values for the CKCUEST in the collegiate baseball population at a community college or NCAA Division III college level. A secondary purpose was to determine if there were differences in CKCUEST scores based on playing position. Once reference data is developed, clinicians may have a quick and easy method to objectively determine if their patient is progressing in their rehabilitation.

METHODS

Subjects

This study was determined to be safe for human subjects by the Institutional Review Board of Arizona School of Health Sciences, A. T. Still University – Mesa Campus. Informed consent was obtained from each subject prior to data collection. The initial sample consisted of 78 collegiate, male baseball players between the ages of 18 and 22 who reported no recent history of injuries to the shoulder, elbow, or the hand-wrist complex. Subjects were recruited from two community colleges in Arizona and one NCAA Division III college in California. Subjects were excluded if they did not meet the age range, they had surgery on either upper extremity within the last year, were not fully cleared by their team physician to participate in practice or competition, or were experiencing pain or fatigue in either upper extremity from recent activity.

Data Collection Procedures

Subjects completed a screening questionnaire to ensure that no recent surgery or injury existed to the shoulder, elbow, and hand-wrist complex. Each subject was then assigned a number for identification. The weight of each subject was measured (in pounds), converted to metric units, and recorded. The height was measured using a standard 10-foot tape measure (in inches), converted to metric units, and recorded. Each player's position was also recorded. Each subject was then given a brief explanation on how to perform the test.

Two strips of athletic tape with a width of 1.5 inches were placed parallel to each other 36 inches apart on a tile floor as measured with a standard tape measure. The starting position for the test is one hand on each piece of tape while assuming a pushup position (Figure). The subjects were instructed that from the starting position they were to use one hand to reach across their body and touch the piece of tape lying under the opposing hand. After touching the tape line the hand would be returned to the original starting position. The subject would perform the same movement with the other hand. Touches were counted as every time the hand reached across the subject's body and touched the tape. The total time for the trial was 15 seconds. Each subject performed a warm up trial and then three real trials of the test with a rest period of 45 seconds between trials. An average of the three trials was used for data analysis.

Figure: *Set-up and starting position of the CKCUEST.*

Table 1: *Descriptive statistics for all players (n = 7)*

	Age (yrs)	Height (m)	Weight (kg)	BMI*
Mean	19.03	1.83	83.5	24.92
SD	1.22	0.08	12.23	2.91
95% CI	0.27	0.02	2.73	0.65

* Body Mass Index

Data Analysis

Descriptive statistics including mean, standard deviation, 95% confidence interval (CI), kurtosis (with 95% CI) and skewness (with 95% CI) were calculated for the number of touches performed for the CKCUEST. In addition, a Kolmogorov-Smirnov Goodness-of-Fit Test was also performed to insure that the data fit the normal distribution. To ensure no differences in scores on the CKCUEST according to player position, a one way analysis of variance was performed to determine differences in the scores among four difference groups: pitchers, catchers, infielders, and outfielders. An alpha level of 0.05 was chosen as the level of significance.

Table 2: *Scores on CKCUEST according to playing position*

Position	n	Mean *	Standard Deviation
Pitcher	30	30.30	4.82
Catcher	9	30.41	3.52
Infielder	26	30.78	4.02
Outfielder	12	30.30	4.00
All Players	77	30.41	3.87

*The number of touches performed on the CKCUEST

RESULTS

Initially, 79 subjects participated in this study. Two subjects were excluded due to upper extremity pain or discomfort while participating in the actual test. The descriptive statistics for the sample can be found in Table 1.

Scores on the CKCUEST can be found in Table 2. As a result of the analysis of variance, no significant difference was found between the scores on the CKCUEST across position ($F = 0.045$; $df = 3,73$; $p = 0.99$). Therefore, the scores on the CKCUEST are not dependent on the position of the baseball player.

A 95% CI was used to test the null hypothesis that the data fit a normal distribution.[7] If zero is included in the range of the confidence interval, the null hypothesis cannot be rejected. Zero was included in the ranges for both skewness and kurtosis, and it can be concluded the data did not differ from a normal distribution. A Kolmogorov-Smirnov Goodness-of-Fit Test was also performed to insure that the data fit the normal distribution, which revealed the data fit a normal distribution ($p = 0.22$).

DISCUSSION

A proliferation of rehabilitation techniques has occurred for the upper extremity using closed-kinetic chain activities.[8] The use of closed-kinetic chain exercises are beneficial for the lower extremity; therefore, it is reasoned closed-kinetic chain exercise is probably beneficial for the upper extremity.[9] Closed-kinetic chain exercises may increase electromyographic activity, improved joint stability and proprioception, and utilize multiple joint involvement.[10] Closed-kinetic chain exercises may provide large resistance with low acceleration, greater compression forces, increased joint congruency, low shear forces, and enhanced dynamic stabilization.[11] Wilk et al[12] proposed closed-kinetic chain exercise for the upper extremity such as isometric press-ups and isometric weight bearing with weight shift for functional tests. Closed-kinetic chain exercise involving weight bearing and shifting during rehabilitation may enhance muscular co-contraction of the glenohumeral joint through joint compression and approximation.[12] These exercises parallel the demands when performing the CKCUEST.

Most common assessments of the upper extremity are performed in an open-kinetic chain fashion, which measure the patient's pathology and levels of strength, stability, proprioception, and range of motion. Yet, assessment of these variables only test part of the role of the upper extremity in its main function; to place the hand/wrist complex in a position to manipulate the environment. When comparing open- and closed-kinetic chain assessments, no relationships exist between the outcomes, suggesting that a complete and thorough assessment of the shoulder must include more simple open-kinetic chain assessments and more complex closed-kinetic chain assessments.[13-15]

Difficulty arises in trying to describe any closed-kinetic chain test that assesses the independent function of the shoulder complex or the elbow complex, as the function of these complexes are not independent from one another and requires coordination between scapular, glenohumeral, elbow, and forearm muscles.[16] This coordination may explain the need for assessment tools that attempt to measure the function of the wrist/hand complex, the elbow complex, and the shoulder complex simultaneously.

Some tests that have been introduced to assess upper extremity function using closed-kinetic chain activities include curl-ups or partial curl-ups, pull-ups, or push-ups tests.[13,14] However, Goldbeck and Davies[4] suggest that no commonly used tests exist in the literature to identify deficits in upper extremity closed-kinetic chain function, which was their justification for developing the CKCUEST.

Ellenbecker[19] reported reference values for the CKCUEST of 18.5 touches for males and 20.5 touches for females (females used a modified starting position). These numbers are drastically different from the results obtained in this study (30.41 touches for males; SD = 3.87). The number of touches recorded for males in Goldbeck and Davies[4,5] study was 27.8 (SD = 1.77). Using 95% confidence intervals to determine differences, a difference does exist in the data collected by Goldbeck and Davies[4,5] (27.09 – 28.51 touches) and the data from this study (29.55 – 34.28 touches).

A major issue with the CKCUEST is the validity of the test. The authors were unable to assess any studies which evaluated the sensitivity and specificity of the test with any pathological conditions at this time. Nor were the authors able to assess the agreement or relationship with any other test used to evaluate function of the upper extremity. Still, the CKCUEST is a published test in the literature and is probably being used in a multitude of settings. Therefore, more descriptive data is needed for clinicians who use the test, which was a major objective in conducting this study.

The current authors had several concerns with the CKCUEST. One possible problem with the CKCUEST is the test places high loads of force on the wrist, elbow, and shoulder. The starting push-up position is not a position that the general population performs regularly. Patients presenting with co-morbidities of the upper extremities may have difficulties performing the task. The body position when performing the test requires a substantial amount of trunk strength or stability and patients who have compromised trunk strength or impairments may not be good candidates for the CKCUEST. The older geriatric population may not be able to perform the test and patients who are susceptible to fracture may be at increased risk because of the force of impact. For an athletic population or a population of conditioned individuals, the test might be perceived as a good functional assessment.

CONCLUSION

Closed-kinetic chain exercise and testing have become popular as it assesses the upper extremity as a unit. The CKCUEST appears to be a clinically useful test for upper extremity function. Reference values have been developed for the CKCUEST for collegiate-level baseball players. No differences existed in scores by position, and the values found in this sample fit a normal distribution.

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